ETACHA 4.9 Model and Version Selection Guide

Ionization, excitation, PWBA corrections, and shell-basis selection

Technical manual revised against the supplied ETACHA papers, workshop material, LISE++ slides, and ETACHA Version 4.9 source code (source identifier 4.9.0, 21-AUG-2026; Codex baseline)

> Bottom line: For robust production calculations, v4 with CDW-EIS ionization and Symmetric-Eikonal excitation is the strongest general starting point supported by the 2015 physics model, not because the GUI says ‘recommended.’ Use v3 when n=4 is demonstrably irrelevant; use the corrected v3.4 as a faster four-shell approximation; use v4.5 only as an upper-shell sensitivity extension. For ibin, keep 0 for established-code continuity, 2 for uncorrected-PWBA diagnostics, and avoid 1 unless deliberately studying that historical binding correction.

1. Scope and source basis

This guide converts the physics statements in the supplied references and the behavior of the latest supplied ETACHA source into practical model-selection rules. Published statements, source-code behavior, and maintainer guidance are kept separate. Where an energy boundary is derived from the perturbation parameter Kp, it is explicitly marked as a practical manual rule rather than a published hard cutoff.

- Lamour et al., Physical Review A 92, 042703 (2015): modern ETACHA23/3/34/4 basis, CDW-EIS ionization, SEIK excitation, Kp discussion, benchmark systems, and shell-basis limitations.
- Rozet, Stephan and Vernhet, NIM B 107, 67-70 (1996): original three-shell ETACHA model; PWBA ionization/excitation with a semi-empirical saturation correction; 10-80 MeV/u GANIL validation and warning at lower velocity/heavier targets.
- Rozet, S3 Workshop 2009: high-velocity validity landmarks and motivation for strong-perturbation extensions.
- ETACHA4-in-LISE++ slides (2016): practical 10-100 MeV/u statement, quality-calculation note for K < 1, Z-q <= 60, and ETACHA5 motivation.
- Supplied ETACHA C++ source (Version 4.9; source identifier 4.9.0, 21-AUG-2026): actual model routing, ibin behavior, equation counts, the v3.4 charge-state correction introduced in 4.8.10, and the v4.5 upper-shell treatment. The 4.8.17-4.8.19 revisions add batch-result diagnostics and, most importantly for model selection, make the ibin mapping explicit and logged; Version 4.9 is the release/Codex baseline following that correction.
- **Provenance note:** GUI annotations such as “fast, for high E,” “corrected!,” “recommended,” “beta,” and model “default” labels were added by the LISE/ETACHA GUI maintainer. They are useful interface guidance, but they are not evidence from Lamour et al. or Rozet et al. The recommendations below are therefore derived from the papers plus executable source behavior, not from those GUI words.

Code point	Date	Meaning for this manual
4.9	21-AUG-2026	Current release/Codex baseline (source identifier 4.9.0), following the ibin mapping correction.
4.8.19	21-AUG-2026	ibin radio-button IDs assigned explicitly by physics meaning; selected ibin value is logged in detailed calculation output.
4.8.18	21-AUG-2026	Batch result CSV adds Kp(1) after target density, useful for automated model-selection diagnostics.
4.8.17	21-AUG-2026	Batch result CSV excludes QM and adds dQ(calc-set)=QF-Qb after iQmax.
4.8.10	14-AUG-2026	Physics-relevant correction: v3.4 charge-state distribution now includes the independent Y(n=4) population; v3.4 was re-enabled.
4.5 / v45 model	Version 4.9 source	Still 1283 coupled population equations, like v4; upper-shell terms are added effectively rather than as a new explicit Y(n=5) population system.

2. The parameter that should drive model selection: Kp

Lamour et al. define the projectile perturbation parameter

$$\mathbf{Kp = (Zt / Zp)\ (ve / vp)}$$

where Zt and Zp are target and projectile atomic numbers, ve is the mean orbital velocity of the active projectile electron, and vp is projectile velocity. The current GUI implements the diagnostic Kp(1)=Zt/vp and displays Kp(n)=Kp(1)/n^2. That n-scaling is a GUI implementation convention and should not be presented as the published Eq. (4) itself. For model selection, target Z, projectile velocity, and the active shell matter more directly than projectile Z alone. Since 4.8.18, the batch result CSV also writes Kp(1) after target density, which makes automated/Codex model-selection checks easier to audit.

Important: There is no single universal “PWBA above X MeV/u” boundary. The same projectile energy can be perturbative on C and strongly distorted on a much heavier target. Use Kp whenever possible.

3. Recommended ionization and excitation models

Kp region	Regime	Ionization	Excitation	Practical manual rule (not a published hard cutoff)
Kp(active) <= 0.1	Weak perturbation / high velocity	PWBA is a reasonable fast/reference choice; CDW-EIS is also valid	PWBA is a reasonable fast/reference choice; SEIK is also valid	PWBA is defensible for scans. For final work, model sensitivity is usually cheap to check.
0.1 < Kp(active) <= 0.4	Transition region	Prefer CDW-EIS for precision	Prefer SEIK for precision	Ionization differences can appear before Kp=1; excitation benchmark has not yet reached the clear ~0.4 breakdown point.
0.4 < Kp(active) <= 1	Moderate/strong distortion	CDW-EIS strongly preferred	SEIK strongly preferred	The 2015 Ar excitation benchmark explicitly shows PWBA overestimation beginning around Kp~0.4.
Kp(active) > 1	Nonperturbative	Use CDW-EIS within ETACHA, with benchmark caution	Use SEIK within ETACHA, with benchmark caution	The elementary-process models are improved, but overall ETACHA accuracy can be limited by capture, screening, and missing upper shells.
Kp(active) > 2	Very strong perturbation	Use only with system-level validation where possible	SEIK has experimental support beyond Kp=2 for the cited Ar transition	Do not generalize one successful elementary-process benchmark into a universal ETACHA validity claim.

Why 0.4 is useful but not universal: for 13.6 MeV/u Ar17+ at fixed projectile velocity, the measured 1s->2p excitation data show PWBA beginning to overestimate at Kp of about 0.4, while SEIK follows the data to Kp values above 2 (Lamour et al., Fig. 3). For ionization, Lamour et al. show that PWBA deviations at low velocity can appear even for Kp<1. Consequently, this manual uses Kp bands as practical guidance, not as universal sharp boundaries.

4. Energy translation of Kp for common solid targets

The following energies are derived from the current GUI approximation Kp(1)=Zt/vp and the relativistic relation between projectile velocity and energy per nucleon. They are not hard validity limits; they are a convenient way to see where a target enters the perturbative or nonperturbative regime for a K-shell-like active electron.

Target	Zt	E at Kp=1 (MeV/u)	E at Kp=0.4 (MeV/u)	E at Kp=0.2 (MeV/u)	E at Kp=0.1 (MeV/u)
H	1	0.025	0.16	0.62	2.49
He	2	0.099	0.62	2.49	10.1
Be	4	0.40	2.49	10.1	42.4
C	6	0.89	5.63	23.2	105
Al	13	4.22	27.4	127	2.01 GeV/u
Si	14	4.90	32.0	152	not reachable (v > c)
Ti	22	12.2	85.5	630	not reachable (v > c)
Fe	26	17.2	127	2.01 GeV/u	not reachable (v > c)
Ni	28	20.1	152	not reachable (v > c)	not reachable (v > c)
Cu	29	21.6	166	not reachable (v > c)	not reachable (v > c)

- Carbon target example: Kp(1)=0.4 at about 5.6 MeV/u, 0.2 at about 23 MeV/u, and 0.1 at about 105 MeV/u. Therefore CDW-EIS/SEIK are sensible final-calculation choices throughout much of the traditional ETACHA energy range on carbon, while PWBA remains useful as a fast/reference calculation when Kp is small enough.
- Aluminum target example: Kp(1)=0.4 occurs near 27 MeV/u. At a few MeV/u, inner-shell collisions are strongly nonperturbative.
- For heavier targets, a truly small Kp for inner-shell processes can require very high energy. Higher shells have much smaller Kp because the GUI estimate scales approximately as 1/n^2.

5. Historical high-velocity landmarks versus the modern models

Projectile	2009 “high-velocity” landmark
C	E >= ~1 MeV/u
Ar	E >= ~8 MeV/u
Kr	E >= ~30 MeV/u
Pb	E >= ~200 MeV/u

The S3 workshop material associates these landmarks with projectile velocity comparable to the 1s electron velocity and K << 1. They describe where the older/high-velocity ETACHA picture had proved accurate, not mandatory lower-energy cutoffs for the 2015 code. The whole purpose of the CDW-EIS and SEIK additions was to extend ETACHA into lower-velocity, stronger-perturbation systems. The 1996 paper reported good agreement over roughly 10-80 MeV/u at GANIL, but explicitly warned that lower velocities and heavier collision partners were not assured in that older formulation.

6. ETACHA version selection: shells, correlations, energy, and Z

Important: The current GUI annotations ("fast, for high E," "corrected!," "recommended," "beta") are maintainer comments, not published validity statements. Version selection below is based on the rate-equation structure and benchmark evidence.

Version	Shell basis	Rate eqs.	Configuration treatment	Recommended use	Caution
v2.3 / ETACHA23	n=1-3	84	K/L correlated; M subshell populations treated separately	Historical three-shell model; useful for legacy reproduction and selected highly stripped systems when upper-shell dynamics are negligible	The 2015 Pb benchmark shows that improved elementary cross sections alone do not rescue an insufficient shell basis.
v3	n=1-3	293	Adds correlated Y(n12,n3)	Fast three-shell production/scan option whenever n=4 occupancy and n=3->4 dynamics are negligible; can also work at very low energy for few-electron ions	Do not equate the GUI phrase "fast, for high E" with a physics validity limit. The 2015 carbon-on-Al benchmark is a counterexample: v3 works well at 0.045-0.5 MeV/u because the shell basis is sufficient.
v3.4 / ETACHA34	n=1-4	326	Adds independent Y(n4) to the v3 system	Corrected fast four-shell approximation; useful for scans, equilibrium/thicker-target work, and sensitivity checks when n=4 matters but n123-n4 correlations are expected to be secondary	Version 4.8.10 fixed the charge-state reconstruction to include Y(n4) and re-enabled v3.4. The 2015 Pb benchmark still shows that independent n4 populations can be inadequate at thin target / near-shell-closure conditions.
v4	n=1-4	1283	Full correlated Y(n123,n4) population system	Most complete published n<=4 basis; preferred when n=4 dynamics matter, for many-electron projectiles up to 60 explicit electrons, and for thin-target nonequilibrium where correlations matter	Required in the 28.9 MeV/u Pb56+ benchmark even though the incident ion has only 26 electrons.

Version	Shell basis	Rate eqs.	Configuration treatment	Recommended use	Caution
v4.5	v4 explicit basis + effective upper-shell terms	1283	Same coupled population count as v4; adds n=5/6-related excitation/loss contributions	Exploratory sensitivity option when n>=5 physics is suspected	The visible GUI "+Y(5)"/"beta" wording is maintainer shorthand. The source does not add a new explicit Y(n=5) rate-equation population system, and the supplied papers do not establish a v4.5 validation range.

7. Practical version rules by bound-electron count, shell dynamics, and Z context

- Nbound = Zp - q <= 28 is necessary for a pure n<=3 occupancy picture, but it is not sufficient to guarantee that v3 is accurate: excitation or capture into n=4 can matter dynamically even when the incident ion has fewer than 28 electrons.
- Projectile Z by itself is not a reliable selector. A high-Z but highly stripped projectile can still be a valid v3 case when Nbound<=28 and n=4 dynamics are negligible; conversely, a lower-Z system can require n=4 at sufficiently low velocity or strong perturbation.
- If n=4 must be included but speed is important, v3.4 (from 4.8.10 onward) is the corrected 326-equation approximation. It treats Y(n=4) independently and is therefore most defensible for scans, thicker-target/equilibrium work, or cases where correlations with n=1-3 are expected to be secondary.
- For 29 <= Nbound <= 60, at least a four-shell basis is required: v3.4 can provide the faster independent-n=4 approximation, while v4 should be used when thin-target nonequilibrium, near-shell-closure populations, or n123-n4 correlations can control the charge-state distribution. The Pb56+ benchmark is the key warning: only 26 incident electrons were present, yet the correlated v4 treatment was required because n=3 -> n=4 dynamics were important.
- Target Z primarily influences the elementary-process model choice through Kp: heavier targets move the same projectile energy toward stronger perturbation and therefore favor CDW-EIS/SEIK over PWBA. It does not create a universal projectile-Z boundary between v3, v3.4, and v4.
- For Nbound > 60, or when n>=5 is dynamically important at low velocity, none of v2.3/v3/v3.4/v4 provides a complete basis. v4.5 can be used only as an exploratory effective upper-shell correction because its explicit population system remains the 1283-equation v4 basis; a true n>=5 population model is needed for quantitative confidence.

8. Benchmarks that anchor the selection rules

System	Energy	Bound e-	Physics indicator	What the supplied source supports
Ar10+ + C	13.6 MeV/u	8	Kp(1s)=0.26; Kp(2p)~0.065	Old/new versions similar; agreement is good. Moderate distortion, but n=4 is not decisive for this case.
Pb56+ + C	28.9 MeV/u	26	vp~34 a.u.; Kp(1s)~0.18	v4 required for good evolution; n=4 and correlated configurations are important.
Pb56+ + Si	28.9 MeV/u	26	Kp increases by ~2.2 vs C	v4 gives clear improvement over v2.3 in stronger perturbation.
C beams + Al	0.045-0.5 MeV/u	<=5	Kp(K shell) ~10 down to 2.9	v3 with CDW-EIS/SEIK reproduces mean charge well; strong evidence that improved cross sections extend the low-energy domain for few-electron projectiles.

System	Energy	Bound e-	Physics indicator	What the supplied source supports
58Ni19+ + Ca/Ti/Cr/Fe	3.5-4.5 MeV/u	9	Strong target-dependent perturbation	2015 conclusion says ETACHA should provide rather reliable data for these S3-type systems.
238U71+ + C	51 MeV/u	21	Moderate Kp on C	v4 predicts measured distribution with good accuracy after RIKEN carbon stripper.
238U38+ + C	11 MeV/u	54	Low velocity; many-electron ion	Supplied paper says n>=5 must be included; v4 is insufficient despite Nbound<60.

9. PWBA correction parameter ibin: empirical saturation, binding, or none

The supplied source defines three options for the Born/PWBA backbone:

Internal value	Meaning	Recommendation	What it does
ibin=0	Empirical saturation correction	Established ETACHA continuity / reproduction	Applies the historical saturation factors to the PWBA ionization/excitation backbone. The original archived FORTRAN hard-codes ibin=0. In the modern scheme the improved-model/PWBA ratio is formed using that selected backbone, then reused as charge and energy evolve.
ibin=1	Binding correction included	Normally avoid; use only for deliberate historical sensitivity studies	Changes binding/energy-transfer factors (epsilon/qmin-type terms) in PION, SEXI and SEX2. The “not recommended” statement already exists in the original FORTRAN source, so it is not merely a GUI annotation.
ibin=2	No empirical correction and no binding correction	Raw-PWBA / model-isolation diagnostic	Leaves the PWBA backbone without either correction. Useful for testing sensitivity and understanding the CDW-EIS/SEIK reduction-factor machinery. The supplied papers do not establish that ibin=2 is generally more accurate than ibin=0 for production work.

How this interacts with CDW-EIS/SEIK: the 2015 method first calculates reference PWBA and improved (CDW-EIS or SEIK) cross sections for hydrogenlike ions, forms reduction factors, then periodically recalculates the faster PWBA-type cross sections as charge and energy change and applies those factors. The current source therefore notes that ibin corrections act only on the PWBA/BORN1 cross sections used for the effective-charge evolution and “should not make much a change.”

The original FORTRAN source in the archive hard-codes ibin=0, consistent with the 1996 ETACHA description of a semi-empirical correction to PWBA. A nearby old comment says the empirical saturation correction had “not [been] used anymore since a long time,” but the executable branch is still present and is executed when ibin=0. The 2015 paper does not publish a validation comparing ibin=0 against ibin=2 inside the modern CDW-EIS/SEIK scheme. Therefore use ibin=0 for continuity/reproduction of the established ETACHA implementation, and use ibin=2 as an uncorrected-PWBA diagnostic—not because the GUI labels one of them as preferred.

Operational recommendation: Use ibin=0 when you want continuity with the established/original ETACHA implementation. Use ibin=2 as a deliberate uncorrected-PWBA sensitivity test. Avoid ibin=1 for routine calculations because the original FORTRAN source itself marks the binding correction ‘not recommended.’ There is no supplied published benchmark proving a universal accuracy ranking between ibin=0 and ibin=2 inside the modern CDW-EIS/SEIK scheme.

10. ETACHA 4.9 correction selector: verified mapping and logging

The ambiguity identified in the earlier 4.8.16 GUI/source audit is resolved in 4.8.19 and carried into Version 4.9. The QButtonGroup IDs are now assigned explicitly by physics meaning: empirical saturation -> ibin=0; binding correction -> ibin=1; no empirical/no binding correction -> ibin=2. The calculation output also writes “PWBA correction parameter ibin=%d”, so the visible selection and the physics value can be checked directly in the detailed log. The .etacha file continues to save the same ibinParameter value. This explicit mapping should be treated as the authoritative Version 4.9 behavior.

11. Decision procedure for a user/manual

1. Determine the incident bound-electron count Nbound = Zp - q and ask whether n=4 or n>=5 can be populated appreciably during the foil traversal.
2. Choose the shell basis from the actual electron structure and target-thickness problem: v3 for a three-shell calculation when n=4 is negligible; v3.4 as the corrected, fast four-shell approximation with independent Y(n=4); v4 when correlation between n=1-3 and n=4 matters; and v4.5 only as an exploratory upper-shell sensitivity extension.
3. Calculate or read Kp for the active shell. Use the GUI Kp values as a quick diagnostic, remembering that Kp falls strongly with n.
4. For final calculations, select CDW-EIS ionization and SEIK excitation unless Kp is safely small and a PWBA speed gain is important.
5. For ibin, distinguish the established ETACHA PWBA backbone (ibin=0) from uncorrected PWBA (ibin=2). Use ibin=2 for sensitivity/model diagnostics. The original FORTRAN source itself labels ibin=1 binding correction as “not recommended.”
6. At low velocity / high target Z / heavy many-electron projectile, check for upper-shell limitations. A good elementary ionization/excitation model does not compensate for a missing shell in the rate-equation basis.
7. For high-stakes predictions, compare neighboring model choices and, where possible, benchmark against measured charge-state distributions.

12. Compact selection table for the ETACHA GUI

Use case	Version	Ionization	Excitation	ibin	Comment
Robust general production; n=4 may matter	v4	CDW-EIS	Symmetric-Eikonal	0 for established-code continuity	This is a physics-based synthesis from the 2015 model/benchmarks, not a conclusion taken from the GUI word “recommended.”
Fast three-shell scan; n=4 demonstrably negligible	v3	PWBA or CDW-EIS	PWBA or SEIK	0 or 2	Choose elementary models from Kp. v3 is not restricted to high energy; it can work at low energy for few-electron systems.
Fast four-shell scan / thicker-target approximation	v3.4 (>=4.8.10)	CDW-EIS	SEIK	0	v3.4 is now corrected/re-enabled. Use when explicit n=4 is needed but full n123-n4 correlation is not expected to control the answer.
Thin target, near closed shell, or correlation-sensitive n=4 dynamics	v4	CDW-EIS	SEIK	0	Prefer the correlated 1283-equation basis; this is where the Pb56+ benchmark most clearly disfavors v3.4.
Weak perturbation, Kp<=~0.1	v3/v3.4/v4 as shell basis requires	PWBA acceptable	PWBA acceptable	0 or 2	Use 2 for raw PWBA. Check once against CDW-EIS/SEIK when precision matters.
Moderate/strong perturbation, Kp>=~0.4	appropriate shell version, usually v4 if n=4 matters	CDW-EIS	SEIK	0	PWBA excitation is specifically disfavored by the cited benchmark; ionization PWBA also degrades as distortion grows.
Suspected n>=5 importance	v4.5 only as sensitivity test	CDW-EIS	SEIK	0	Do not claim full five-shell accuracy; the explicit population basis is still the v4 1283-equation system.
Raw-PWBA diagnostic	any appropriate shell version	PWBA	PWBA	2	Useful to isolate the effect of empirical saturation and improved-model scaling.
Binding-correction study	any appropriate shell version	PWBA backbone affected	PWBA backbone affected	1	Historical/research sensitivity only; original source marks it not recommended.

13. What should and should not be called “validated”

- Directly supported: SEIK improves excitation in the strong-perturbation test and remains good past Kp=2 for that measured Ar transition; CDW-EIS improves low-velocity ionization relative to PWBA.
- Directly supported: v4 is superior for the 28.9 MeV/u Pb56+ carbon benchmark and is required to represent n=4 dynamics correctly there.
- Directly supported: v3 can work extremely well at very low energy for a few-electron light projectile (laser-generated carbon on Al), because the shell basis remains sufficient while CDW-EIS/SEIK handle strong perturbation.
- Directly supported limitation: 11 MeV/u U38+ on C indicates the need for n>=5 even though v4 nominally handles up to 60 electrons.
- Not supported by the supplied papers: a universal projectile-Z boundary separating v3 and v4, a universal energy cutoff between PWBA and CDW-EIS/SEIK, or a validated energy/Z range for v4.5.

14. Proposed manual/help wording (physics-derived; not copied from GUI annotations)

Ionization: “CDW-EIS should be preferred when collision distortion is not safely small, especially at moderate/low projectile velocity or larger target Z. PWBA is the perturbative reference and can be useful for fast scans and model comparisons in the weak-perturbation regime.”

Excitation: “Symmetric-Eikonal should be preferred outside the weak-perturbation regime. In the cited Ar17+ 1s->2p benchmark, PWBA begins to overestimate at Kp of roughly 0.4, while SEIK remains in good agreement to substantially larger Kp.”

Correction: “ibin=0 applies the empirical saturation correction used by the established ETACHA implementation; ibin=1 applies the binding correction and is explicitly marked ‘not recommended’ in the original FORTRAN source; ibin=2 uses PWBA without either correction.”

Version: “v3 solves the 293-equation three-shell system; v3.4 solves 326 equations and adds an independent n=4 population (its charge-state output was corrected and re-enabled in 4.8.10); v4 solves the correlated 1283-equation n<=4 system; v4.5 keeps the same 1283 populations and adds effective upper-shell excitation/loss terms, so it is not a full explicit five-shell rate-equation model.”

15. Source-code audit notes

- e_Donaut4.cpp: IonizationModel==0 calls Tceis/CDW-EIS for 1s, 2s, 2p and uses Z/n scaling for higher shells; ExcitationModel==0 calls the SE calculation and forms reduction factors relative to the PWBA backbone.
- e_Donaut4.cpp defines the physics meanings: ibin=0 empirical saturation, ibin=1 binding correction (not recommended), ibin=2 no correction; corrections apply only to PWBA/BORN1 cross sections. In Version 4.9, e_mainwindow.cpp assigns those three IDs explicitly to the corresponding visible radio buttons, e_fileReadWrite.cpp saves/loads ibinParameter, and e_Etacha4_print.cpp logs the selected numeric ibin value.
- e_Etacha4.cpp: equation counts are 84 (v2.3), 293 (v3), 326 (v3.4), and 1283 for both v4 and v4.5. In 4.8.10, v3.4 charge-state reconstruction was corrected so the independent Y(n=4) population contributes to PR, and the v3.4 option was re-enabled.
- e_Donaut4.cpp / e_CSresults.cpp: v4.5 exposes n=5/6 cross-section contributions and adds excitation-to-n=5 terms to effective loss, but does not increase the number of coupled population equations beyond v4.
- e_mainwindow.ui (Version 4.9): v3 is annotated “fast, for high E,” v3.4 “corrected!,” v4 “recommended,” and v4.5 “beta.” These words are LISE/ETACHA GUI maintainer annotations supplied by O. Tarasov, not statements from the ETACHA papers; this manual therefore does not use them as independent physics evidence.

References

[1] E. Lamour et al., “Extension of charge-state-distribution calculations for ion-solid collisions towards low velocities and many-electron ions,” Physical Review A 92, 042703 (2015). DOI: 10.1103/PhysRevA.92.042703.

[2] J. P. Rozet, C. Stephan, D. Vernhet, “ETACHA: a program for calculating charge states at GANIL energies,” Nuclear Instruments and Methods in Physics Research B 107 (1996) 67-70.

[3] J.-P. Rozet, “Towards improvement of ETACHA for S3 ions,” S3 Workshop presentation, 2009 (supplied file Rozet_S3WS09.pdf).

[4] O. B. Tarasov, “Implementation of the ETACHA4 code to the LISE++ package / Current LISE++ Development: ETACHA4,” 2016 slides (supplied file EtachaLISE.pdf).

[5] Supplied ETACHA source archive, Version 4.9 (source identifier 4.9.0), 21-AUG-2026. Relevant recent revisions in e_ftype.h: 4.8.10 (14-AUG-2026), v3.4 charge-state distribution includes independent Y(4) population and the v3.4 option is re-enabled; 4.8.17, batch CSV removes QM and adds dQ(calc-set)=QF-Qb after iQmax; 4.8.18, batch CSV adds Kp(1) after density; 4.8.19, ibin radio-button IDs are assigned by physics meaning and logged explicitly; 4.9.0 is the release/Codex baseline following the ibin mapping correction. Principal files audited: win/e_ftype.h, win/e_mainwindow.ui, win/e_mainwindow.cpp, win/e_fileReadWrite.cpp, win/e_CSresults.cpp, source/e_Etacha4_print.cpp, source/e_Donaut4.cpp, source/e_Pion.cpp, source/e_Sexi.cpp, source/e_Sex2.cpp, source/e_Etacha4.cpp, source/e_F4.cpp, and source_Original/porting/Donaut4.for.