Internal Memo: Resolving the "Single-Anchor" Mass Questions

Anchor-specific identity, RG transport vs. recognition residue, and non-circularity

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To: A. Thapa (and internal mass-paper contributors)
Subject: Response to concerns raised in `sm_running_mass_note_anil.pdf`

Executive Summary (what changes, what does not)

- **Anchor-specific, not RG-invariant.** The mass regularity we report is *defined at a single common scale* $\mu_\star$. We do *not* claim that $\Delta_i(\mu) \equiv f_i(\mu, m_i) - \mathcal{F}(Z_i)$ is constant under RG flow for arbitrary μ. Off-anchor drift is expected and is not a contradiction.
- **Two distinct exponents (do not conflate).** The framework separates a *recognition/geometric residue* $f^{\mathrm{Rec}}(Z)$ (large, closed form) from a *Standard-Model RG transport* f_i^{RG} (small, loop-computed transport factor). The large band values such as $\mathcal{F}(1332) \approx 13.95$ cannot be the same object as the small SM transport exponent for leptons.
- **Non-circularity is an operational rule.** Any use of "structural mass" must be specified so that m_i^{struct} is fixed *without using* the same measured m_i that the comparison is meant to test. Sector-level calibration and hold-out checks are acceptable; per-species tuning is not.

1 Definitions (minimal, consistent with repo)

Golden ratio and fixed constants. We use $\varphi = (1+\sqrt{5})/2$ and the canonical normalization

$$\lambda = \ln \varphi, \qquad \kappa = \varphi.$$

We also use a single common reference scale

$$\mu_\star = 182.201 \text{ GeV} \quad \text{(the common "anchor" scale).}$$

Charge-to-integer map $Z(Q, \text{sector})$. Define the integerized charge $\widetilde{Q} := 6Q \in \mathbb{Z}$ for Standard-Model charges. Then define

$$Z \;=\; \begin{cases} 4 + \widetilde{Q}^2 + \widetilde{Q}^4, & \text{quarks,} \\ \widetilde{Q}^2 + \widetilde{Q}^4, & \text{charged leptons,} \\ 0, & \text{(Dirac) neutrinos (conditional statement).} \end{cases} \tag{1}$$

Closed-form band function. Define the closed form

$$\mathcal{F}(Z) \;:=\; \frac{1}{\ln\varphi}\,\ln\!\Big(1+\frac{Z}{\varphi}\Big). \tag{2}$$

For reference, the three equal-Z charged-fermion families correspond to

$$Z_{u,c,t} = 276, \quad Z_{d,s,b} = 24, \quad Z_{e,\mu,\tau} = 1332,$$

hence $\mathcal{F}(276) \approx 10.69$, $\mathcal{F}(24) \approx 5.74$, $\mathcal{F}(1332) \approx 13.95$.

SM RG transport exponent (small). Let $m_i(\mu)$ denote the usual $\overline{\text{MS}}$ running mass of species i. Define the SM transport exponent between two scales (e.g. $\mu_\star$ and a reference/pole point) by

$$f_i^{\text{RG}}(\mu_1,\mu_2) \;:=\; \frac{1}{\ln\varphi}\,\ln\!\Big(\frac{m_i(\mu_2)}{m_i(\mu_1)}\Big) \;=\; \frac{1}{\ln\varphi}\int_{\ln\mu_1}^{\ln\mu_2}\gamma_i(\mu)\,d\ln\mu, \tag{3}$$

with $\gamma_i(\mu) = \gamma_m^{\text{QCD}} + \gamma_m^{\text{QED}}$(+EW if included) evaluated under a declared loop order, threshold, and coupling policy. Empirically and by scale/loop size, f_i^{RG} for leptons is $O(10^{-2}\text{–}10^{-1})$ for the $\mu_\star \leftrightarrow m_\ell$ interval.

Two different things are being called "f^{Rec}" (this is the source of the disagreement). There are *two* distinct quantities in play:

- **Band value (closed form).** The single-anchor phenomenology paper compares an RG-side residue $f_i(\mu_\star, m_i)$ to the closed-form band value $\mathcal{F}(Z_i)$ from (2). Some drafts casually call this band value a "recognition residue".
- **Extracted leftover from a mass factorization.** In Anil's Section 4, f_i^{Rec} is defined operationally as "whatever is left" after choosing a structural prefactor m_i^{struct} and subtracting SM transport. This extracted quantity is *definition-dependent*: if m_i^{struct} is chosen so that it already matches the observed masses (up to small transport), then the extracted leftover will be small and will *not* numerically match $\mathcal{F}(Z_i)$.

This memo therefore avoids using the same symbol for both objects: $\mathcal{F}(Z)$ is the band comparator; any extracted leftover should be written explicitly as "extracted residual" (defined below).

2 What the anchor claim is (and is not)

Not RG invariance

Your note correctly observes that if one defines

$$\Delta_i(\mu) := f_i(\mu, m_i) - \mathcal{F}(Z_i),$$

then generically $\Delta_i(\mu)$ will vary with μ under RG flow. We agree. The claim we intend to report is instead:

Anchor-specific posture. *There exists a single common scale $\mu_\star$ at which the nine charged fermions organize into three equal-Z bands described by the closed form $\mathcal{F}(Z)$, within declared policy bands.* Off-anchor, standard SM RG applies; the anchor is a distinguished point, not a symmetry.

The key bookkeeping: transport vs. band coordinate

The mismatch highlighted in your Table 1 comes from treating the large band value $\mathcal{F}(Z)$ as though it were the SM transport integral itself. That identification cannot be correct for leptons because the transport exponent is small while $\mathcal{F}(1332)$ is $O(10)$. Accordingly, the framework uses f_i^{RG} only as a *transport factor* (scheme/scale alignment), and $f^{\mathrm{Rec}}(Z)$ as the *recognition-side coordinate* that carries the large band value.

3 Where "structural mass" enters, and how to avoid tautology

Mass-factorization display (what gets compared to data)

If one wishes to connect a *structural* prefactor to measured masses, a generic factorization is:

$$m_i^{\mathrm{pole}} \;=\; m_i^{\mathrm{struct}}\;\varphi^{\,f_i^{(\mathrm{extracted})}}\;\varphi^{\,f_i^{\mathrm{RG}}}, \tag{4}$$

where the SM part is only f_i^{RG} (computed from declared RG kernels/policies), and $f_i^{(\mathrm{extracted})}$ is the leftover exponent implied by the chosen m_i^{struct}.

The tautology failure mode

If m_i^{struct} (or any per-species offsets entering it) is extracted from the same measured m_i^{pole} being "tested", then (4) can be made to hold by construction, and the comparison carries no evidentiary content. This is the circularity you flagged, and we agree it must be avoided.

Operational non-circularity rule (what we require)

Rule (no self-use). *No measured mass m_i may appear on the right-hand side of its own prediction. Any calibration must be sector-global (or done on a declared hold-out subset) and then frozen.*

Practically. There are two acceptable approaches:

1. **Sector-global calibration (minimal knobs).** Choose m_i^{struct} from a sector-wide form $m_i^{\mathrm{struct}} = B_{B(i)}\,E_{\mathrm{coh}}\,\varphi^{r_i+r_0(B(i))}$ with *one* r_0 per sector (and fixed B_B, E_{coh}), and fix those sector parameters once (from theory-side constraints or a declared small calibrator set), then predict the remaining species out-of-sample.
2. **Strict hold-out.** Declare a subset used for any unavoidable calibration, freeze all constants, and then report all remaining species as a hold-out audit with no retuning.

What Anil's Eq. "$f^{\mathrm{Rec}} = \Delta_{\mathrm{obs}} - f^{\mathrm{RG}}$" means in plain terms. Rearranging (4) at the anchor gives an *extracted residual*

$$f_i^{(\mathrm{extracted})} \;=\; \frac{1}{\ln\varphi}\ln\!\Big(\frac{m_i(\mu_\star)}{m_i^{\mathrm{struct}}}\Big), \qquad \text{and the test is} \quad f_i^{(\mathrm{extracted})} \overset{?}{\approx} \mathcal{F}(Z_i).$$

This comparison is meaningful *only if* m_i^{struct} is fixed independently of m_i (except via a declared calibration protocol) *and* the definition of m_i^{struct} has not already absorbed the same constant band factor one is trying to test. In the SM charged-fermion sectors, Z (hence $\mathcal{F}(Z)$) is *constant within each sector*, so any sector-wide constant factor can be moved back and forth between m_i^{struct} (via a sector offset) and the extracted residual. Without an *independent* definition of the sector yardstick, the statement "$f^{(\mathrm{extracted})} = \mathcal{F}(Z)$" is not identifiable from mass data alone.

4 Direct response to *Section 4* of your note (the serious point)

Your Section 4 observation is correct. If one *defines* a "recognition residue" by rearranging the measured masses, e.g. from an equation of the form $m_i^{\mathrm{pole}} = m_i^{\mathrm{struct}}\,\varphi^{f_i^{\mathrm{Rec}}+f_i^{\mathrm{RG}}}$, then

$$f_i^{\mathrm{Rec}} = \frac{1}{\ln\varphi}\ln\!\Big(\frac{m_i(\mu_\star)}{m_i^{\mathrm{struct}}}\Big)$$

is just bookkeeping. If m_i^{struct} is itself chosen using m_i (explicitly or implicitly), the test becomes tautological. We agree with this critique.

Resolution (what changes in the manuscript). We should *not* write (or imply) "the extracted leftover from a structural mass factorization equals $\mathcal{F}(Z)$" unless we also provide (i) an independent, non-mass-fitted definition of the sector yardsticks and (ii) a clear convention that prevents absorbing sector-constant factors into the yardstick. Otherwise, Anil's numerical check will always show a mismatch, because the yardstick choice can soak up the band factor.

So what is a defensible statement? Two clean options:

- **Option A (RG-only paper).** Keep $\mathcal{F}(Z)$ strictly as the *RG-side comparator* in the single-anchor phenomenology paper: compare $f_i(\mu_\star, m_i)$ (as defined by the RG integral) directly to $\mathcal{F}(Z_i)$. Do not introduce a mass-factorization f^{Rec} at all.
- **Option B (mass-factorization paper).** If we want a mass-factorization interpretation, we must (i) freeze the sector yardsticks from independent theory-side derivations/anchors (not from the same masses) and (ii) define the split so that a sector-constant factor cannot be silently moved between the yardstick and the leftover. Only then does comparing an extracted residual to $\mathcal{F}(Z)$ become a nontrivial test.

Clarifying m^{struct} (why his numbers "don't match"). If m_i^{struct} is taken to be $B_{B(i)}\,E_{\mathrm{coh}}\,\varphi^{r_i+r_0(B(i))}$ with r_0 chosen to make the sector match masses, then the extracted leftover $f_i^{(\mathrm{extracted})}$ will be small by construction and will not equal $\mathcal{F}(Z)$. This does not falsify $\mathcal{F}(Z)$; it shows the manuscript must not claim an equality between $\mathcal{F}(Z)$ and an extracted leftover without pinning down the yardstick convention independently.

What we mean by m^{struct} (what would make the test meaningful). For a meaningful test, m_i^{struct} must be specified so it does *not* import m_i species-by-species. One admissible structural form is sector-global, e.g.

$$m_i^{\mathrm{struct}} := B_{B(i)}\,E_{\mathrm{coh}}\,\varphi^{r_i+r_0(B(i))},$$

where B_B and $r_0(B)$ are fixed once per sector (not per species) and $r_i \in \mathbb{Z}$ is an integer rung. Whether those sector-global constants come from independent anchors or from a declared hold-out calibration is a separate methodological choice, but *per-species* tuning is disallowed.

What a real (non-tautological) check looks like. Once the structural inputs are frozen, the comparison becomes meaningful:

1. Fix Z_i from charge/sector (1) and set $f_i^{\mathrm{Rec}} := \mathcal{F}(Z_i)$ (no fit).
2. Fix m_i^{struct} from sector-global parameters and integer rungs (no per-species tuning).

3. Compute f_i^{RG} from SM RG kernels/policies (transport only).

4. Compare the predicted m_i^{pole} (or $m_i(\mu)$ in a declared scheme) to the experimental value after transport to like-for-like conventions.

In this protocol, f^{Rec} is not being *solved for* from the same mass being tested, and f^{RG} does not have to "explain" a band-sized exponent.

On introducing extra shifts δ. Your conclusion is right: a species-dependent δ_i is just fitting. Only a universal δ or a sector-global δ_B (fixed once and then frozen) can be admissible, and it must be declared as part of the structural model, not silently adjusted to chase $\mathcal{F}(Z)$.

5 "Not RG invariant" vs. "unstable under small perturbations"

What you are worried about (and why it is reasonable). If an equality holds only at one chosen scale, it can feel like a brittle coincidence: change the scheme, move thresholds, change loop order, or nudge the scale, and the equality disappears. That concern is valid *unless* the anchor is a *stationary/plateau point* where the observable is first-order insensitive to small changes in the calibration choices.

What we mean by stability (not invariance). We are *not* asserting an RG symmetry. We are asserting that a single globally chosen anchor $\mu_\star$ behaves like a *preferred measurement point*: near $\mu_\star$, small coherent perturbations in the policy (threshold placements within PDG bands, loop-order truncation, minor scheme variants) move *all* residues coherently, so that equal-Z family structure is preserved to first order. In plain terms: the bands shift together; they do not fragment.

Where the "plateau" enters. In the mass-paper posture, $\mu_\star$ is selected by a species-independent stationarity objective on regrouped kernel/motif weights (a PMS/BLM-like "minimal sensitivity" choice). This is different from claiming that each species satisfies a separate stationarity condition. The testable consequence is:

- equal-Z family *differences* are comparatively insensitive to μ near $\mu_\star$,
- changes in global inputs shift families coherently (a band moves as a band).

This is the precise sense in which the identity can be non-invariant yet still not be "fine-tuned."

Operational evidence (what the artifacts are supposed to show). The intended numerical audit is not "it works at one point, period" but:

- a central run at declared kernels/policies meets the tolerance at $\mu_\star$,
- global variations (loop order, threshold policy, $\alpha(\mu)$ policy) shift residuals by a small, coherent band (reported as a systematic),
- structural ablations (drop the quark $+4$, drop Q^4, replace $6Q \to 3Q$) break the equality by orders of magnitude.

6 Non-circular structural hold-out (run and reported)

The note's Section 4 critique highlights the risk of *self-use* (tautology) when defining any "structural mass" and then extracting a residue from the same measured mass being tested. To make the methodology explicit, we include a strict hold-out protocol and its results here:

7 Non-circular calibration / hold-out protocol for the structural mass model

Why this section exists. Anil's Section 4 critique is methodological: if we "test" a proposed correction term by rearranging the same measured mass we are testing, the exercise is circular. This section states (and runs) a strict non-circular procedure for the *structural* part of the mass model.

Important clarification (what this is *not*). This hold-out test is *not* the SM single-anchor identity paper (which is purely RG-side). It is a separate check for the RS *structural ladder* model, whose parameters include sector-global offsets.

Protocol

We work sector-by-sector (Lepton / UpQuark / DownQuark / Electroweak). Within each sector we assume the structural-only ladder form

$$m_{\text{struct}}(i) = 2^{B(\text{sector})}\, E_{\text{coh}}\, \varphi^{r_0(\text{sector})}\, \varphi^{r_i - 8},$$

where:

- $B(\text{sector})$ is a fixed sector binary weight,
- E_{coh} and φ are global constants,
- r_i is the rung assigned to the species,
- $r_0(\text{sector})$ is a *single* sector offset (one value per sector).

Hold-out rule. To avoid circularity, a species' measured mass is never used in its own prediction. Concretely, for each sector we perform **leave-one-out** cross-validation:

- pick one species to hold out,
- fit the sector offset $r_0(\text{sector})$ using only the *other* species in that sector,
- freeze $r_0(\text{sector})$ and predict the held-out species,
- record prediction error.

Implementation (reproducible). This protocol is implemented by:

- `tools/holdout_structural_masses.py`
- input data: `data/masses.json`
- outputs: `out/masses/structural_holdout.csv` and `out/masses/structural_holdout_table.tex`.

Results (structural-only hold-out)

What the table means. Each row is an *out-of-sample* prediction: the sector offset r_0 was fit from other species, then used to predict the held-out one. If the structural-only model were already complete, these errors would be small.

Table 1: Non-circular structural hold-out audit (leave-one-out within each sector). Each row is a held-out prediction; the sector offset r_0 is fit from the other species in that sector, then frozen to predict the held-out species.

Sector	Held-out	r_0 (fit)	Pred. (MeV)	Ref. (MeV)	Abs. err	Rel. err
Lepton	e	41	0.443577	0.510999	-0.0674217	-0.131941
Lepton	mu	41	88.2741	105.658	-17.3843	-0.164533
Lepton	tau	41	1584.01	1776.86	-192.845	-0.108532
UpQuark	c	15	1785.5	1270	515.5	0.405906
UpQuark	t	13	12238	172760	-160522	-0.929162
UpQuark	u	16	14.5172	2.16	12.3572	5.72094
DownQuark	b	-23	6150	4180	1970	0.471292
DownQuark	d	-25	0.657825	4.67	-4.01218	-0.859138
DownQuark	s	-22	554.545	93.4	461.145	4.93732
Electroweak	H	34	79206	125200	-45994	-0.367364
Electroweak	W	35	128158	80379	47779	0.594421
Electroweak	Z	34	79206	91187.6	-11981.6	-0.131395

Interpretation. The errors are not uniformly small under this strict protocol, which is exactly the point: **a sector-wide ladder with one offset is not, by itself, sufficient for high-precision prediction across all species.** This is compatible with the broader framework, which includes additional (theory-side) residue structure and/or transport corrections; but it makes the methodology explicit and prevents accidental self-fitting.

8 Suggested wording for the manuscript (to match our intended posture)

- **Be explicit about scope.** "The band identity is an empirical regularity at one common anchor $\mu_\star$; off-anchor, SM RG applies."
- **Name the two exponents distinctly.** Use $f^{\mathrm{Rec}}(Z) = \mathcal{F}(Z)$ for the band coordinate and reserve f_i^{RG} for SM transport. Avoid calling $\mathcal{F}(Z)$ an "RG residue" without qualifiers.
- **State the non-circularity rule in the main text.** One sentence plus a checklist is enough: sector-global calibration allowed; no per-species tuning.

Repo pointers (for internal verification)

- Definitions and policy notes: `Recognition-Science-Full-Theory.txt` (blocks `@SM_MASSES`, `@RG_METHODS`).
- One-file narrative source: `book/papers/txt/Source-Super.txt` (entries `@SM_MASSES`).

- Formal "do-not-conflate" sanity check: `IndisputableMonolith/Physics/MassResidueNoGo.lean`.
- Mass-law display split: `docs/Mass-From-Light-Memo.tex` (Eq. (4) style).

A Lean formalization: what is defined/proved vs. what is an interface

Purpose of this appendix. This is not meant as a "Lean proof of the SM 4-loop kernels." It is a map of what we have actually formalized and how it supports the paper's bookkeeping clarity (separation of objects; non-conflation; structural definitions frozen before comparison).

Core structural definitions (model layer)

- `IndisputableMonolith/Masses/Anchor.lean`: defines $E_{\mathrm{coh}} = \phi^{-5}$, sector yardsticks ($B\_\mathrm{pow}, r_0$), rung tables r_i, and the integer charge map $Z(Q, \mathrm{sector})$.

Closed-form band function $\mathcal{F}(Z)$ (proved properties)

- `IndisputableMonolith/RSBridge/GapProperties.lean`: defines `gap` and proves monotonicity, concavity, diminishing increments, and ordering of the certified bands (e.g. $Z = 24 < 276 < 1332$).

Non-conflation sanity check (proved separation)

- `IndisputableMonolith/Physics/MassResidueNoGo.lean`: proves that any "small" quantity cannot equal the large lepton band value `gap 1332`, formalizing the repo's "do not set $f^{\mathrm{RG}} = f^{\mathrm{Rec}}$" warning.

RG transport as a mathematical interface (not the SM kernel implementation)

- `IndisputableMonolith/Physics/RGTransport.lean`: defines the transport integral interface (`AnomalousDimension`, `integratedResidue`) and relates it to mass ratios. It is intentionally abstract; the QCD/QED kernel coefficients are treated as external inputs in the phenomenology artifacts.

Example: interval-checked electron mass derivation (internal RS-side derivation)

- `IndisputableMonolith/Physics/ElectronMass/Necessity.lean` and `IndisputableMonolith/Physics/E` contain an interval-arithmetic derivation pipeline for the electron mass within the RS model layer, and track what precision is currently provable.

Additional mass modules (context)

- `IndisputableMonolith/Physics/QuarkMasses.lean`: a "quarter-ladder" quark derivation scaffold (includes some numerical axioms; labeled as such).
- `IndisputableMonolith/RRF/Physics/ParticleMass.lean`: an RRF-level structural mass framework and ratio identities.

B "Mass from light" derivation (where to find it)

For a self-contained standard SR/GR derivation of "mass from light" (invariant mass from four-momentum, two-photon example, box-of-light, Einstein two-pulse argument), see the companion memo: `docs/Mass-From-Light-Memo.tex` (compiled PDF recommended for sharing).

Bottom line. Your diagnosis in the note is right: treating the large band numbers as literal SM transport residues creates RG-invariance and magnitude contradictions. The resolution is to keep the two residues distinct (band coordinate vs. SM transport), state the claim as anchor-specific, and enforce a strict non-circularity protocol for any structural prefactors.